

A Note For Graphing Calculators In The Fundamental Finance Course

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ABSTRACT

The financial calculator is incorporated in finance education. In class, the instructor shows students how to use the financial calculator's function keys to solve time value of money (TVM) related problems efficiently. The fundamental finance course is required for all majors in the business school. Some students, especially non-accounting/non-finance majors, still want to use their graphing calculators rather than purchase financial calculators to save the cost. In fact, graphing calculators, such as TI-83 Plus and TI-84 Plus, also contain finance functions and many undergraduate students had owned TI-83 Plus or TI-84 Plus before they took the fundamental finance course in the junior year. This note provides a perspective that instructors of the undergraduate fundamental finance course may consider teaching students how to use finance functions of the graphing calculator in addition to teaching students how to use the financial calculator in class.

Keywords: Graphing Calculators; Fundamental Finance Course; Time Value of Money

INTRODUCTION

The technological advancement has integrated the financial calculator with finance education in business schools. In general, basic finance textbooks show how to utilize the financial calculator's function keys to solve problems when presenting the chapter materials for time value of money (TVM) and its applications. Popular financial calculators, such as TI-BA II Plus (Business Analyst), TI-BA II Plus (Professional), HP-10BII, HP-12C, and HP-17BII+, are available in the market. In the fundamental finance course, the instructor selects a financial calculator and teaches students how to use its function keys to solve TVM-related problems in class.¹ Due to powerful functions of financial calculators, students are able to compute answers more efficiently than using the traditional way of looking up TVM tables.

Based on my observation during these years of teaching, graphing calculators, such as TI-83 Plus and TI-84 Plus, are very popular among undergraduate students. Some of them had purchased graphing calculators in their high school stage to facilitate learning quantitative courses and prepare for ACT/SAT tests. Others bought graphing calculators in the early years of college life to take college algebra or basic statistics. The price of a graphing calculator (TI-83 Plus), which is around \$100, is the substantial amount for an undergraduate student who already purchased TI-83 Plus.²

The fundamental finance course is required for all different majors (accounting, finance, human resources management, logistics management, management information systems, marketing, etc.) in the business school and students generally take it in the junior year. Therefore, a fundamental finance class consists of business school students with different majors. Many undergraduate students are sensitive about their educational expenditures. Some of non-accounting/non-finance majors who had owned graphing calculators (TI-83 Plus or TI-84 Plus) may not want to spend additional money to purchase a financial calculator because they may think that the fundamental finance course is the only finance course required to take if they do not take any other finance course(s) as

¹ Depending on schools, the title of fundamental finance course is principles of finance, business finance, foundations of financial management, etc.

² The price of TI-84 Plus is higher than that of TI-83 Plus.

elective(s). They may not want to buy financial calculators for only a fundamental finance course; they just want to use graphing calculators they already own.

The graphing calculator (TI-83 Plus or TI-84 Plus) cannot only be used in mathematics, calculus, and basic statistics courses, but also in the fundamental finance course because TI-83 Plus or TI-84 Plus contains basic finance functions, which can efficiently handle most of the basic TVM-related problems. If graphing calculator users also know how to use finance functions, they can better utilize their calculators and get their calculator investment rewarded.

Financial calculators have more powerful functions to deal with complicated and advanced TVM-related problems. Finance majors need to use financial calculators to solve problems in advanced finance courses. This note does not intend to challenge an important role that the financial calculator plays in finance education. This note provides a perspective that instructors of the undergraduate fundamental finance course may consider teaching students how to use finance functions of the graphing calculator in addition to teaching students how to use the financial calculator in class.³ After completing the course, the graphing calculator users will be able to apply finance functions to manage basic personal/corporate financial issues.

In the following section, two examples are displayed to show the step-by-step procedures of utilizing finance functions of the graphing calculator (TI-83 Plus) to solve TVM-related problems.⁴

EXAMPLES OF USING FINANCE FUNCTIONS OF THE GRAPHING CALCULATOR TO SOLVE TVM-RELATED PROBLEMS

Example 1: Find the Yield for a Treasury Security

A Treasury note, which will mature in two years, sells for 99.80394 percent of the face value. Its face value is \$1,000. It has a 1.5 percent annual coupon rate and makes semiannual payments. What is its yield?

Solution

In this example, the Treasury note (T-note) is sold for 99.80394 percent of the face value. The face value (or called par value) is \$1,000. Therefore, the T-note is sold at $\$1,000 \times 99.80394\% = \998.0394 (or \$998.04 if round to 2 decimal places).

The yield (or called yield to maturity) represents the annual rate of return an investor can earn if he or she holds the T-note until maturity. The equation of semiannual coupon bond valuation is as follows:

$$PV = \sum_{t=1}^N \frac{PMT}{(1 + \frac{y}{2})^t} + \frac{FV}{(1 + \frac{y}{2})^N} = PMT \left(\frac{1 - \frac{1}{(1 + \frac{y}{2})^N}}{\frac{y}{2}} \right) + \frac{FV}{(1 + \frac{y}{2})^N} \quad (1)$$

where:

PV = Value of the bond

N = Number of half-year (6-month)

PMT = Semiannual coupon payment (= annual coupon rate \times face value \div 2)

y = Bond's yield (yield to maturity)

FV = Bond's face value (par value), which is \$1,000.

³ When teaching students how to use finance functions of the graphing calculator in class, instructors can use TI-SmartView, emulator software for TI-83 Plus and TI-84 Plus to demonstrate step-by-step procedures to students.

⁴ The finance functions of TI-83 Plus are the same as those of TI-84 Plus. So, the step-by-step procedures can also be used for TI-84 Plus.

Without using the graphing or financial calculator, students need to use the trial-and-error method to approximate y , which is very time-consuming and inefficient. To find the yield faster, we can use the finance functions built into the TI-83 Plus.

Method 1: Calculate $I\%$ in TVM Solver

Turn on TI-83 Plus and press **APPS** (see Figure 1). Then choose **1:Finance** (press 1 or press **ENTER** if the cursor blinks on **1:Finance**); then Figure 2 appears. Under the finance menu, choose **1:TVM Solver** (press 1 or press **ENTER** if the cursor blinks on **1:TVM Solver**).

```

APPLICATIONS
1:Finance...
2:CBL/CBR
3:Prob Sim
4:SciTools
5:StudyCrd

```

(Figure 1)

```

F1: VARS
1:TVM Solver...
2:tvm_Pmt
3:tvm_I%
4:tvm_PV
5:tvm_N
6:tvm_FV
7:↓nPV(

```

(Figure 2)

Then we see five variables (N , $I\%$, PV , PMT , FV), P/Y , C/Y , and PMT : END/BEGIN on the screen. P/Y and C/Y represent number of payments and number of compounding per year, respectively. In finance, we generally set both of them at 1. Because the semiannual coupon payments are made at the end of each half-year (6-month), make sure that PMT is on END mode. Since we want to find the y (yield), we have to compute $I\%$. Move the cursor by using \blacktriangle and \blacktriangledown to input $N = 2 \times 2 = 4$, $PV = -\$998.0394$, $PMT = 1.5\% \times \$1,000 \div 2 = \7.5 , and $FV = \$1,000$ (see Figure 3).⁵ To calculate $I\%$, move the cursor to " $I\% =$ ". Then, press the green key **ALPHA** and then **ENTER** (means **SOLVE**). After that, we will see $I\% = 0.799999$, as shown on Figure 4.

```

N=4
I% = █
PV = -998.0394
PMT = 7.5
FV = 1000
P/Y = 1
C/Y = 1
PMT: [END] BEGIN

```

(Figure 3)

```

N=4
I% = .7999992045
PV = -998.0394
PMT = 7.5
FV = 1000
P/Y = 1
C/Y = 1
PMT: [END] BEGIN

```

(Figure 4)

$I\% = 0.799999$ represents the semiannual rate, $y/2$. The y (yield) is the annual rate. So, we can use \blacktriangleright to move the cursor to the right end of $I\%$ and then multiply by 2 to compute the yield (see Figure 5). Therefore, the yield = $0.799999\% \times 2 = 1.599998\% \approx 1.6\%$ (see Figure 6). If the T-note investor holds the T-note until maturity, his or her annual rate of return would be 1.6%.

⁵ The signs of PMT and FV should be the same. But the sign of PV should be opposite to the signs of PMT and FV . From the T-note holder perspective, PV is the T-note holder's cash outflow and PMT and FV are the T-note holder's cash inflows. That means the T-note holder pays \$998.0394 to Treasury today to buy the T-note. Later, Treasury will make semiannual coupon payments of \$7.5 at end of each half-year (6-month) for two years and face value payment of \$1,000 at maturity (end of two years).

```
N=4
I%=...99992045*2■
PV=-998.0394
PMT=7.5
FV=1000
P/Y=1
C/Y=1
PMT: [END] BEGIN
```

(Figure 5)

```
N=4
I%=1.599998409
PV=-998.0394
PMT=7.5
FV=1000
P/Y=1
C/Y=1
PMT: [ ] [ ] BEGIN
```

(Figure 6)

Method 2: Calculate IRR

Another method to find the yield is to calculate internal rate of return (IRR). IRR is the discount rate which makes net present value (NPV) equal to zero. The relationships are shown in equation (2). CF_0 is negative because it is a cash outflow for initial investment. We can rearrange equation (2) to get equation (3). $-CF_0$ becomes positive. So, equation (3) means that IRR is the discount rate which makes present value of future cash flows (CF_t) equal to the initial cost of investment ($-CF_0$).

$$NPV = 0 = CF_0 + \sum_{t=1}^N \frac{CF_t}{(1 + IRR)^t} \quad (2)$$

$$-CF_0 = \sum_{t=1}^N \frac{CF_t}{(1+IRR)^t} \quad (3)$$

Applying the bond valuation to IRR method, we can find that $y/2$ in equation (1) is just like IRR in equation (3). $y/2$ is the discount rate that makes the present value of future semiannual coupon payments and face value payment at maturity equal to the bond's value.⁶ Again, without using the graphing or financial calculator, students need to use the trial-and-error method to approximate IRR, which is very tedious and time-consuming. The procedures of using TI-83 Plus to find the IRR are as follows.

Turn on TI-83 Plus. First, press **STAT** key to see Figure 7. Then, select **1:Edit** by pressing 1 (or **ENTER** if the cursor is flashing on **1:Edit**). We will see columns L1, L2, and L3 on the screen (Figure 8).

```

0000 CALC TESTS
0001 Edit...
0002 SortA(
0003 SortD(
0004 ClrList
0005 SetUpEditor

```

(Figure 7)

L1	L2	L3
████████	-----	-----
L1() =		

(Figure 8)

Suppose we would like to input the cash inflow stream in column L1. Since the 2-year T-note pays coupons semiannually, there should be four coupon payments. In addition, the face value of \$1,000 will be paid at maturity. Therefore, we input semiannual coupon payments of \$7.5 (CF_1 to CF_3) three times ($L1(1) = L1(2) = L1(3) = 7.5$) and the last payment (CF_4) should be $\$7.5 + \$1,000 = \$1,007.5$ ($L1(4) = 1,007.5$) (see Figure 9). After

⁶ Apply the bond valuation to IRR method so equation (1) is the same as equation (3). Thus, $PV = -CF_0$, $PMT = CF_t$ (for $t = 1$ to $N-1$), and $PMT + FV = CF_t$ (for $t = N$).

finishing with inputting the cash inflow stream from L1(1) to L1(4), as shown on Figure 10, we press **2nd** **QUIT** to return to the standard screen.⁷

L1	L2	L3	1
7.5	-----	-----	
7.5			
7.5			
1007.5			
L1(4)=1007.5			

(Figure 9)

L1	L2	L3	1
7.5	-----	-----	
7.5			
7.5			
1007.5			
L1(5)=			

(Figure 10)

To find the IRR, press **APPS** and then choose **1:Finance**. Then select **8:irr** by pressing 8 (or **ENTER** if we arrow down the cursor to **8:irr**) (see Figure 11). We will see “irr(“ on the screen, as shown on Figure 12.

```

VARs
2:tvm_Pmt
3:tvm_I%
4:tvm_PV
5:tvm_N
6:tvm_FV
7:nPV(
8:irr(

```

(Figure 11)

```
irr(
```

(Figure 12)

The syntax to find IRR is `irr(CF0, CF list)`. CF₀ is the initial cash outflow (negative), which is the price the investor pays today to buy the T-note. So, we input -998.0394 for CF₀. CF list is the column where we store the cash inflow stream. We store the cash inflow stream in column L₁, so we input L₁. The way to input L₁ is to press **2nd** **1**. After finishing the syntax `irr(-998.0394, L1)`, we press **ENTER** and IRR of 0.799999 is shown (Figure 13). Since $0.799999\% = y/2$, the semiannual rate, we need to multiply by 2 to convert to the yield, the annual rate. Finally, the yield = $0.799999\% \times 2 = 1.599998\% \approx 1.6\%$ (Figure 14).

```

irr(-998.0394,L1
)
.7999992046

```

(Figure 13)

```

irr(-998.0394,L1
)
.7999992046
Ans*2
1.599998409

```

(Figure 14)

After we get the answer, if we want to clear data of cash inflow stream inputted in column L₁, we can press **STAT** and then select **4:ClrList** (means clear list) (see Figure 15). Input L₁ and then press **ENTER**. We will see **Done**, which means the L₁ cash inflow stream has been cleared (see Figure 16).

⁷ If the bond's time to maturity is very long (for instance, longer than 10 years), this method may not be efficient and using it is not suggested because the bond's cash inflow stream in column L₁ would be very long and it is very time-consuming to input all of cash inflows.

```

5000 CALC TESTS
1:Edit...
2:SortA(
3:SortD(
4:ClrList
5:SetUpEditor

```

(Figure 15)

```

ClrList L1
Done

```

(Figure 16)

Method 3: Solve the Yield for the Equation of Bond Valuation

As discussed earlier, the equation of semiannual coupon bond valuation is shown in equation (1), which is:

$$PV = PMT \left(\frac{1 - \frac{1}{(1 + y/2)^N}}{y/2} \right) + \frac{FV}{(1 + y/2)^N}$$

In this example, $PV = \$998.0394$, $PMT = \$7.5$, $N = 4$, $FV = \$1,000$. We can plug these numbers in the above equation; then it will be as follows. Based on the following expression, we solve y .

$$0 = -998.0394 + 7.5 \left(\frac{1 - \frac{1}{(1 + y/2)^4}}{y/2} \right) + \frac{1000}{(1 + y/2)^4}$$

Turn on TI-83 Plus and press **MATH**, then Figure 17 shows up. Then select **0:Solver** and the screen will be displayed as in Figure 18.

```

MATH NUM CPX PRB
4:J(
5:J(
6:fMin(
7:fMax(
8:nDeriv(
9:fnInt(
0:Solver...

```

(Figure 17)

```

EQUATION SOLVER
eqn: 0=

```

(Figure 18)

Use X (press **X,T,O,n**) to substitute $y/2$ ($X = y/2$) and then input the right-hand-side of equation as shown in Figure 19.⁸ To solve X, press **ALPHA** **ENTER**; then $X = 0.00799999$ will appear (Figure 20). $X = 0.00799999 = 0.799999\% = y/2$. Therefore, $y = 0.799999\% \times 2 = 1.599998\% \approx 1.6\%$.

```

EQUATION SOLVER
eqn: 0 = -998.0394 +
7.5*((1-1/(1+X)^
4)/X)+1000/(1+X)
^4

```

```

-998.0394+7.5...=0
X=.00799999204...
bound=(-1E99,1...

```

(Figure 19)

(Figure 20)

Example 2: Calculate the Effective Annual Rate

You are considering for a new loan. The bank charges 9.6 percent compounded monthly on its new loan. What is the effective annual rate (EAR)?

Solution

The quoted rate for a loan from the bank is the nominal rate (or called annual percentage rate (APR)). However, the borrower pays for the effective annual rate (EAR), which is the actual rate charged by the bank. The equation to convert from the nominal rate to the EAR is as follows:

$$EAR = \left(1 + \frac{r_{nom}}{m}\right)^m - 1 \quad (4)$$

where:

EAR = Effective annual rate

r_{nom} = Nominal rate (or called APR)

m = Number of compounding per year

Without using the finance function, students need to plug r_{nom} and m in equation (4) to calculate the EAR. In this example, $r_{nom} = 9.6\% = 0.096$ and $m = 12$ (monthly compounding).

$$EAR = \left(1 + \frac{0.096}{12}\right)^{12} - 1 = (1 + 0.008)^{12} - 1 = 1.100339 - 1 = 0.100339$$

Therefore, EAR is 10.0339% (or 10.03% if rounded to 2 decimal places).

We can also convert from EAR to the nominal rate. We can base on equation (4) and rearrange it to find the equation for the nominal rate, which is as follows:

$$r_{nom} = m \left((1 + EAR)^{\frac{1}{m}} - 1 \right) \quad (5)$$

We just computed $EAR = 10.0339\% = 0.100339$. Now, we plug EAR and $m = 12$ in equation (5) to get

⁸ We can also input the equation as $0 = -998.0394 + 7.5/(1+X) + 7.5/(1+X)^2 + 7.5/(1+X)^3 + 1007.5/(1+X)^4$ in this example and then solve X. However, if N (number of years $\times 2$) is very large, this way of expression would be very long and it is time-consuming to input.

$$r_{nom} = 12((1 + 0.100339)^{\frac{1}{12}} - 1) = 12(1.008 - 1) = 12 \times 0.008 = 0.096.$$

So, we can use equation (5) to convert EAR back to the nominal rate = 9.6%.

Using the finance function built in the graphing calculator, students can calculate the EAR faster. Turn on TI-83 Plus and press **APPS**. Then choose **1:Finance**. Under the finance menu (see Figure 21), choose “**C:►Eff()**” by arrowing down to “**C:►Eff()**” and then press **ENTER** or directly press **C** (press **ALPHA** **PRGM**). “**►Eff()**” shows up (Figure 22).

```

1: F1 VARS
2: F2 InPV(
3: F3 irr(
4: F4 bal(
5: F5 ΣPrn(
6: F6 ΣInt(
7: F7 ►Nom(
8: F8 ►Eff(

```

(Figure 21)

```
►Eff(■
```

(Figure 22)

The syntax to compute EAR is $\text{Eff}(r_{nom}, m)$. Our r_{nom} is 9.6% and $m = 12$ (monthly compounding). Input “9.6, 12” to make $\text{Eff}(9.6, 12)$ (Figure 23) and then press **ENTER** to get 10.0339. Therefore, EAR is 10.0339% (Figure 24).

```
►Eff(9.6,12)■
```

(Figure 23)

```
►Eff(9.6,12)
10.03386937
```

(Figure 24)

To convert back to the nominal rate given the EAR, we can use “**B:►Nom()**” function from finance menu to find the nominal rate. First press **APPS** and then choose **1:Finance**. Under the finance menu (see Figure 25), choose “**B:►Nom()**” by arrowing down to “**B:►Nom()**” and then press **ENTER** or directly press **B** (press **ALPHA** **APPS**). “**►Nom()**” shows up (Figure 26).

```

1: F1 VARS
2: F2 InPV(
3: F3 irr(
4: F4 bal(
5: F5 ΣPrn(
6: F6 ΣInt(
7: F7 ►Nom(
8: F8 ►Eff(

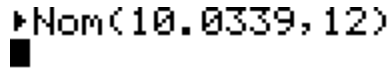
```

(Figure 25)

```
►Nom(■
```

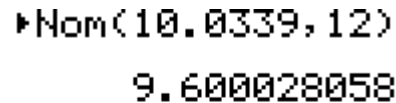
(Figure 26)

The syntax to compute the nominal rate is $\text{Nom}(\text{EAR}, m)$. Input “10.0339, 12)” to make $\text{Nom}(10.0339, 12)$ (Figure 27) and then press **ENTER** to get 9.6 (Figure 28). Therefore, r_{nom} (the nominal rate) is 9.6%.



▶Nom(10.0339, 12)

(Figure 27)



▶Nom(10.0339, 12)
9.600028058

(Figure 28)

CONCLUSION

The detailed steps of using the finance functions of the graphing calculator to solve basic TVM-related problems are shown in this paper. Through the above demonstration, we see that the steps of using finance functions are not complicated and it is not difficult to learn them. Learning how to use finance functions is not only helpful to students in a course, but it is also beneficial to them in the future. After becoming familiar with finance functions, users of graphing calculators can apply them to manage basic personal/corporate financial issues for making better financial decisions.

AUTHOR INFORMATION

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